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The Spherical Model of Color Discrimination Based on Human VEP Data

Chingis Izmailov[1], Evgenii Sokolov & Svetlana Korshunova

Department of Psychophysiology
Moscov State University
Mohovaya 8/5, 103009 Moscow, Russia
[1]chaizm@mail.ru

The study of color discrimination in humans using multidimensional scaling of large color differences has revealed that construction of uniform color space in which Euclidean distances between color points will strictly correspond to perceived color differences is possible when light stimuli varying on spectral distributions and luminance can be represented as a points on a surface of a hypersphere in four-dimensional Euclidean space. Three spherical coordinates of the color hypersphere match subjective attributes of colors: hue, saturation, and brightness, while four Cartesian coordinates represent four neuronal channels (red-green, blue-yellow, bright, and dark) of the visual system. A subset of equibright colors forms three-dimensional Euclidean subspace in which color points are located on a two-dimensional spherical surface. (Izmailov and Sokolov, 1984, 1991; Izmailov, 1995). Color functions calculated from spherical model are in good coincide with psychophysial and neurophysiological data of color vision (Izmailov, 1980, Izmailov, Sokolov, Chernorizov, 1989). Cortical evoked potentials in human were studied to obtain direct electrophysiological measures of color differences and to compare them with color discrimination data obtained by psychophysical methods. The analysis of evoked potentials was different from traditional experimental techniques by two basic peculiarities. Firstly, instead presentation of separate light flash, the instant (with front no more than 0.5 ????) substitution of one flash of light on the other was used. Evoked potential was recorded on this change (Paulus et. al., 1984; Zimzchev et. al., 1986). Secondly, the difference between changed stimuli in pair was increased monotonicaly till both legs from zero point, in which changed stimuli were identical. For the specification of color components series of such functionally connected evoked potentials on stimuli substitutions are used rather then separate evoked potentials (Zimzchev et. al., 1986, Izmailov et. al., 1998). Experiments with pair substitution of five color stimulus (four basic colors - red, blue, yellow, green - and white color) each varying on seven levels of luminance and 12 equibright colors were spend. A color coding component N87 and luminance coding component P120 were reliably found in occipital (O1,O2) and temporal (T5,T6) loci. (Paulus et. al., 1984; Regan, 1989). However, analysis of latency and amplitude of components N87 and P120 depending on differences of luminances between stimulus with identical and different spectral distributions in a pair has shown, that N87 reflects not only color, but also the brightness differences. It allows to connect N87, as one of earliest component with a N1 in cortical evoked potential in primate, reflecting activity of cells, receiving the information directly from NGB and to consider it as the first stage of the cortical analysis of chromatical and achromatical characteristics of light (Padmos, Van Norren, 1975; Zrenner, 1983). Concerns to P120 traditionally interpreted as brightness component, it represents activity of cortical cells connected to the analysis of non-chromatic characteristics of stimulus, such as the form, movement, orientation and etc., which are also based on luminance gradient and contrast, but not directly connected with brightness of light. It explains long latency and high amplitude of P120, in comparison with N87, and also correlation P120 with the configurative characteristics of stimulus, that is refered in a number of works (Regan, 1989). For a comparison of the evoked potentials with subjective estimates of color differences three indexes were used: amplitudes of components N87 and P120 relatively to background and interpeaks amplitude (between N87 and P120). Scatter diagrams between subjective estimates of color differences and these indexes are drawn. The highest correlation with psychophysical estimates of color differences is shown by interpeaks amplitudes for temporal electrode site T5. Using the interpeaks amplitudes as measures of color differences for twelve stimuli color space had been constructed by multidimensional scaling technique. The color points were located on the spherical surface in three-dimensional Euclidean space in exactitude as wall as in case of subjective estimating of these color differences.

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